METEOROLOGICAL REGISTRATIONS IN SAMOA. 1902-1906. II. RAINFALL.[1]

By OTTO TETENS, Ph. D. Dated Berne, Switzerland, March 9, 1909.

INSTRUMENT.

The self-registering raingage was one designed by Professor Hellman and constructed by Fuess. The receiving area is 200 square centimeters. There are two chambers, the upper one of small diameter empties its contents by means of a syphon, as soon as 10 millimeters of rain water have been collected, into the lower and larger vessel. The larger vessel serves as a reservoir and the quantity collected therein is measured daily by means of a glass graduate. The upper chamber also contains a float to which is attached a pen registering the height of the water (from 0–10 millimeters) on a drum which revolves once in about 26 hours. Owing to the small diameter of the upper vessel, the scale of rainfall is highly magnified showing 0.1 millimeter. This instrument was erected at Apia in as favorable an exposure as was possible. The surrounding cocoanut palms, viewed from the raingage, did not exceed an altitude of 45 degrees. It is difficult to say whether the palms have in general affected the catch of the gage; occasional comparisons were made with raingages placed near by and the results were in satisfactory agreement.

[1] For I. Winds, see Monthly Weather Review, March, 1909, 37:93-5.

MONTHLY RAINFALL.

The separate months.

The following table, Table 1, gives for each month the duration, intensity, and quantity of rain, and summary of rainfalls.

Although the rainy season in Samoa is not so pronounced as in some other countries, yet it is very distinct. This is especially true of the northern coast of Upolu where the trade winds, during the dry season, come from a more southerly direction and the north coast thus becomes the lee shore. During the rainy season the winds blow from a more northerly direction and the north coast is then the weather shore. On the south coast the influence of the wind is just contrary to the above, and the two seasons are therefore more equal. In order to contrast the two seasons the months have been grouped under them so that now the tables begin with November, the first month of the wet season. The observations recorded embrace 4 wet and 4 dry seasons.

TABLE 1.—*Observed rainfall data for Apia, Samoa, 1902–06.*

Months.	Duration. Number of rain days.					Number of rain hours.					Number of rain minutes (: 1,000).				
	1902–1903.	1903–1904.	1904–1905.	1905–1906.	1906.	1902–1903.	1903–1904.	1904–1905.	1905–1906.	1906.	1902–1903.	1903–1904.	1904–1905.	1905–1906.	1906.
Wet season.															
November	19	23	22	14	21	95	120	84	82	132	2.1	3.3	1.6	2.5	4.3
December	14	20	24	19	25	65	127	151	84	137	1.7	3.3	3.5	2.5	4.8
January	23	23	22	18	.....	165	202	140	79	.....	5.4	5.9	3.8	2.1	.....
February	21	27	15	18	.....	159	200	60	75	.....	5.2	6.3	1.8	2.1	.....
March	16	20	19	24	.....	99	120	39	128	.....	2.7	3.3	2.9	4.3	.....
April	20	27	19	23	.....	148	199	107	84	.....	4.8	5.9	3.9	1.9	.....
Dry season.															
May	15	19	7	16	.....	88	83	37	76	.....	2.0	1.8	0.6	2.3	.....
June	17	12	11	19	.....	112	56	80	92	.....	2.9	1.1	2.0	2.4	.....
July	13	13	10	17	.....	57	65	34	73	.....	1.2	1.7	0.7	1.8	.....
August	17	18	13	20	.....	85	122	69	115	.....	1.6	3.3	2.1	3.1	.....
September	17	21	10	14	.....	78	93	44	66	.....	1.7	2.8	1.5	1.9	.....
October	20	16	14	20	.....	136	65	41	61	.....	3.8	2.0	1.4	2.1	.....
Year.	212	244	186	222	.....	1,287	1,452	936	1,015	.....	35.1	40.9	25.9	29.0	.....
Dry season	113	145	121	116	.....	731	968	631	532	.....	22.1	28.1	17.5	15.4	.....
Wet season	99	99	65	106	.....	556	484	305	483	.....	13.0	12.8	8.4	13.5	.....
Character:															
Dry season	(+0.06) −0.11	+0.16 −0.13	+0.18 −0.26	+0.14 (−0.04)	.....	(+0.12) −0.18	+0.27 −0.21	+0.22 −0.28	+0.14 (−0.04)	.....	(+0.23) −0.28	+0.34 −0.24	+0.23 −0.29	+0.16 (−0.06)	.....
Wet season															

Months.	Intensity. Centimeters per 1,000 rain minutes.					Quantity. Centimeters.					Rainfalls. Total number of rainfalls.					Rainfalls of more than one hour's duration.				
	1902–1903.	1903–1904.	1904–1905.	1905–1906.	1906.	1902–1903.	1903–1904.	1904–1905.	1905–1906.	1906.	1902–1903.	1903–1904.	1904–1905.	1905–1906.	1906.	1902–1903.	1903–1904.	1904–1905.	1905–1906.	1906.
Wet season.																				
November	10	7	10	7	7	20	23	17	17	31	78	102	68	56	79	8	11	5	15	22
December	5	9	7	7	6	9	28	26	17	27	49	113	125	57	93	9	11	12	11	22
January	7	11	10	7	.....	38	68	38	14	.....	113	174	127	55	.....	23	21	10	14	.....
February	14	10	8	6	.....	71	64	14	14	.....	117	146	46	54	.....	20	27	10	13	.....
March	6	8	8	11	.....	16	27	22	48	.....	82	94	54	89	.....	8	26	16	29	.....
April	8	8	5	7	.....	37	50	21	14	.....	117	168	59	72	.....	24	23	16	8	.....
Dry season.																				
May	6	10	2	8	.....	12	18	1	18	.....	70	75	34	60	.....	7	2	2	13	.....
June	9	11	7	7	.....	26	12	15	16	.....	103	49	69	71	.....	17	3	7	8	.....
July	6	6	8	4	.....	7	11	6	8	.....	45	51	24	59	.....	7	11	4	7	.....
August	6	3	6	4	.....	10	10	13	12	.....	75	106	43	88	.....	5	14	10	15	.....
September	11	7	6	5	.....	18	21	10	9	.....	73	74	28	47	.....	5	12	6	9	.....
October	9	7	4	5	.....	32	15	5	10	.....	116	52	26	39	.....	19	5	8	9	.....
Year.	8.5	8.5	7.6	6.7	.....	297	347	186	193	.....	1,038	1,204	703	747	.....	152	166	106	151	.....
Wet season	8.6	9.3	7.8	7.9	.....	191	260	137	122	.....	556	797	479	383	.....	92	119	69	90	.....
Dry season	8.2	6.7	5.8	5.3	.....	106	86	49	71	.....	482	407	224	364	.....	60	47	37	61	.....
Character:																				
Wet season	(+0.03) −0.04	+0.10 −0.10	+0.10 −0.13	+0.16 (−0.18)	.....	(+0.26) −0.32	+0.44 −0.34	+0.32 −0.42	+0.32 (−0.24)	.....	(+0.06) −0.14	+0.26 −0.18	+0.20 −0.28	+0.13 (−0.02)	.....	(+0.19) −0.24	+0.35 −0.28	+0.22 −0.33	+0.28 (−0.17)	.....
Dry season																				

"Character" of seasons defined.—The total amounts for the year and the two seasons give some interesting facts. The *character* of the one season in comparison to that of the preceding and following one is here expressed by a figure which is obtained by taking the difference of logarithms for the season in question and for the geometric mean of the two contiguous seasons. This definition of "character" does not apply to the first and last seasons observed as these lack either a preceding or succeeding season; therefore the "character" of such a season has been derived by comparison with one season only and its weight is $\frac{1}{2}$. In the tables the figures representing this character are in ( ).

Duration of rain.—The duration of rain has been expressed separately by the number of rain days, rain hours, and rain minutes, for which the mean "characters" are 0.15, 0.20 and 0.24, respectively, showing that through the rain minutes the seasons receive their most potent character.

Rain intensity.—The rain intensity does not characterize the seasons even as well as do the number of rain days, the resulting mean "character" by intensity being only 0.11. As the depth or quantity is equal to the product of duration and intensity, the "character" by quantity equals the sum of the "characters" by duration and intensity. For this reason the quantity of rain is the most important element in characterizing the seasons; the mean seasonal "character" by rain quantity is 0.35. The mean seasonal "character" by the number of rainfalls is 0.18, but by those of more than one hour's duration, 0.27. The different rain features for the two seasons as observed at Apia for eight seasons, when arranged according to their mean "characters" rank as follows:

	Mean seasonal "character."
1. Rain quantity	0.35
2. Rainfalls of more than one hour's duration	0.27
3. Duration by rain minutes	0.24
4. Duration by rain hours	0.20
5. Rainfalls	0.18
6. Duration by rain days	0.15
7. Intensity	0.11

A longer period of observation will undoubtedly change the above averages, as the data for the single years vary greatly. In this respect the values of the individual months show the greatest variations, but the seasonal and even the yearly totals are likewise remarkable. If we consider only the last-named, the ratio of the largest and smallest of the four totals is 1.3, 1.6, 1.6, for the rain days, rain hours, and rain minutes, and 1.3 and 1.9 for intensity and quantity, while the number of rainfalls shows the extreme ratio 1.7 and the rainfalls of more than one hour's duration, 1.6. Thus the four years of observation have sufficed to determine fairly well the average rain intensity and the annual number of rain days, whereas it will require a much longer series of observations to determine equally well the average quantity. However, it is well known that precipitation is everywhere an irregular element.

Average for four years.

The average monthly values of the precipitation features for the four years, 1902–06, are given in Table 2. The "seasonal ratio" is obtained by dividing the average for the wet season by the average for the dry season. The logarithm of the seasonal ratio is equivalent to the mean seasonal "character." The maximum and minimum values of the various factors here presented fall in various months, being found in all the months excepting November and December. It will be interesting to learn, if, after a longer series of observations is available, the same characteristics for each month which appear in the 24 columns of Table 2 will be essentially changed. In this respect Table 1 of this chapter throws some light upon this speculation as the data for each month are given. Some months show decided variations, and it may be safely expected that these fluctuations will recur in later years. In order to show these fluctuations more clearly the quantity and duration "characters" for each month have been calculated and these are given in Table 3.

As the division of the year into 12 months is an accidental one from a meterological point of view while the rainfall is the basis of the seasonal division, the meteorological "character" for the single month cannot be expected to be as steady as is the seasonal character. The unsteady character of the single months appears in Table 3.

TABLE 2.—*Average rainfall data, November, 1902, to October, 1906, at Apia, Samoa.*

Months.	Duration.						Intensity.				Quantity.		Percentages.			Distribution.			Rainfalls.					
	Monthly number of			Daily number of		Hourly number of rain min.	Centimeters per									Rain hours per rain day.	Rain minutes.		Number of rainfalls.		Average rainfall.		Rainfalls of more than 1 hour's duration.	
																							Number.	
	Rain days.	Rain hours.	Rain min. (:1,000).	Rain hours.	Rain minutes.		Rain day.	24 rain hours.	24×60 rain minutes.	1,000 rain minutes.	Monthly.	Daily.	Rain days per 100 days.	Rain hours per 100 hours.	Rain minutes per 100 minutes.		Per rain day.	Per rain hour.	Monthly.	Daily.	Quantity.	Duration.	Per month.	Per 100 rainfalls.
Wet season.							*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*									*cm.*	*min.*		
November	20	95	2.4	3.2	79	3.3	1.0	4.8	12	8.0	19	0.64	65	13	5.5	4.9	122	25	76	2.5	0.29	31	10	13
December	19	107	2.8	3.4	89	3.8	1.0	4.5	10	7.2	20	0.64	64	14	6.2	5.5	144	26	86	2.8	0.23	32	11	13
January	23	146	4.3	4.7	139	5.8	1.8	6.4	13	9.1	39	1.27	73	20	9.7	6.4	190	30	117	3.8	0.33	37	17	14
February	20	124	3.8	4.4	136	5.7	2.0	7.8	15	10.1	40	1.38	72	18	9.5	6.1	190	31	91	3.2	0.45	42	18	19
March	20	109	3.3	3.5	107	4.5	1.4	6.2	12	8.6	28	0.92	64	15	7.4	5.5	167	30	80	2.6	0.36	41	20	25
April	22	134	4.1	4.5	138	5.8	1.4	5.4	11	7.3	30	1.01	74	19	9.6	6.0	186	31	104	3.5	0.29	40	18	17
Dry season.																								
May	14	71	1.7	2.3	54	2.2	0.9	4.1	10	7.2	12	0.39	46	10	3.3	5.0	118	24	60	1.9	0.20	28	6	10
June	15	85	2.1	2.8	70	2.9	1.1	4.8	12	8.0	17	0.56	49	12	4.9	5.7	143	25	73	2.4	0.23	29	9	12
July	13	58	1.3	1.9	43	1.8	0.6	3.3	8	5.8	8	0.25	43	8	3.0	4.4	101	23	45	1.4	0.18	30	7	16
August	17	98	2.5	3.2	81	3.4	0.7	2.7	6	4.4	11	0.36	55	13	5.7	5.8	149	26	78	2.5	0.14	32	11	14
September	16	70	2.0	2.3	65	2.7	0.9	4.9	11	7.4	14	0.48	57	10	4.5	4.6	127	28	56	1.8	0.26	35	8	14
October	18	76	2.3	2.5	75	3.1	0.9	4.9	10	6.7	16	0.50	56	10	5.2	4.3	134	31	58	1.9	0.27	40	10	18
Year.	18	98	2.7	3.2	90	3.7	1.2	5.2	11	7.8	21	0.70	59	13	6.2	5.4	152	28	77	2.5	0.28	35	12	16
Dry season	21	119	3.5	3.9	115	4.8	1.4	6.0	12	8.5	30	1.00	68	16	8.0	5.8	168	29	92	3.1	0.32	38	15	17
Wet season	15	76	2.0	2.5	65	2.7	0.8	4.1	9	6.5	13	0.42	50	10	4.5	4.9	130	26	62	2.0	0.21	32	9	14
Seasonal ratio *	1.3	1.6	1.7	1.6	1.8	1.8	1.7	1.4	1.3	1.3	2.3	2.4	1.4	1.6	1.8	1.2	1.3	1.1	1.5	1.5	1.5	1.2	1.8	1.2

*= mean Wet ÷ mean Dry.

TABLE 3.—*Variations in quantity and duration of rainfall at Apia, Samoa, expressed by the respective "characters."*

Month.	Quantity.							Duration.						
	1902–1903.	1903–1904.	1904–1905.	1905–1906.	1906.	Average.	Mean departure from average.	1902–1903.	1903–1904.	1904–1905.	1905–1906.	1906.	Average.	Mean departure from average.
Wet season.														
November	(+0.34)	−0.12	−0.07	+0.24	+0.27	+0.11	0.18	(+0.06)	−0.02	−0.22	+0.11	+0.13	+0.01	0.11
December	−0.48	−0.15	+0.01	+0.04	(−0.05)	−0.13	0.16	−0.28	−0.13	+0.15	+0.05	(+0.05)	−0.04	0.15
January	+0.20	+0.20	+0.30	−0.03	.....	+0.17	0.10	+0.25	+0.11	+0.19	−0.04	.....	+0.13	0.09
February	+0.41	+0.17	−0.33	−0.26	.....	−0.01	0.30	+0.13	+0.16	−0.28	−0.15	.....	−0.04	0.18
March	−0.48	−0.31	+0.13	+0.54	.....	−0.03	0.36	−0.27	−0.27	+0.04	+0.34	.....	−0.04	0.23
April	+0.42	+0.36	+0.64	−0.33	.....	+0.27	0.30	+0.32	+0.38	+0.46	−0.22	.....	+0.24	0.22
Dry season.														
May	−0.40	−0.14	−1.25	+0.08	.....	−0.43	0.41	−0.28	−0.14	−0.63	+0.04	.....	−0.25	0.20
June	+0.43	−0.06	+0.79	+0.13	.....	+0.32	0.29	+0.29	−0.20	+0.46	+0.07	.....	+0.16	0.22
July	−0.32	−0.01	−0.38	−0.25	.....	−0.24	0.12	−0.27	−0.05	−0.44	−0.19	.....	−0.24	0.12
August	−0.09	−0.16	+0.24	+0.15	.....	+0.04	0.16	+0.05	+0.18	+0.29	+0.24	.....	+0.19	0.08
September	+0.02	+0.22	+0.06	−0.08	.....	+0.06	0.08	−0.16	+0.03	−0.06	−0.13	.....	−0.08	0.06
October	+0.20	−0.09	−0.37	−0.23	.....	−0.12	0.18	+0.20	−0.02	−0.12	−0.13	.....	−0.02	0.11

From the column "Mean Departures" of Table 3 it can be seen that the five months, February to June, are the most inconsistent ones both in quantity and duration of rainfall.

DAILY RAINFALL.

TABLE 4.—*Daily rainfall period at Apia, Samoa. Mean hourly values,* 1903–1906.

	Quantity. Thousandths of a centimeter.			Duration. rain minutes.			Intensity. Thousandths of a centimeter per rain minute.		
	Year.	Wet season.	Dry season.	Year.	Wet season.	Dry season.	Year.	Wet season.	Dry season.
0–1 a. m.	33	43	22	3.9	4.6	3.2	8.0	9.2	6.9
1–2 a. m.	26	30	22	3.8	4.4	3.1	7.0	6.9	7.1
2–3 a. m.	32	52	12	4.0	4.8	3.1	7.4	10.8	3.9
3–4 a. m.	34	60	9	4.1	5.7	2.6	7.0	10.6	3.4
4–5 a. m.	30	49	11	4.1	5.6	2.7	6.5	8.9	4.1
5–6 a. m.	29	45	13	4.3	5.3	2.8	6.2	7.7	4.7
6–7 a. m.	28	48	10	3.8	5.1	2.4	6.6	9.3	3.9
7–8 a. m.	27	40	15	3.7	5.0	2.4	7.2	8.0	6.3
8–9 a. m.	26	36	16	3.7	4.7	2.6	6.8	7.7	5.9
9–10 a. m.	26	32	20	3.6	4.5	2.8	7.2	7.1	7.3
10–11 a. m.	22	28	16	3.4	4.5	2.3	6.5	6.2	6.8
11–12 a. m.	26	32	21	3.4	4.2	2.6	7.8	7.6	8.0
Noon.									
0–1 p. m.	27	42	12	3.3	4.4	2.2	7.5	9.4	5.6
1–2 p. m.	26	36	17	3.8	5.0	2.7	6.7	7.1	6.3
2–3 p. m.	40	54	26	4.3	5.5	3.1	9.2	9.8	8.5
3–4 p. m.	32	36	28	4.4	5.4	3.3	7.6	6.6	8.7
4–5 p. m.	37	54	20	4.6	5.9	3.3	7.6	9.2	6.1
5–6 p. m.	38	50	27	4.1	5.6	2.7	9.4	8.9	10.0
6–7 p. m.	31	42	20	4.2	5.4	3.0	7.4	7.9	6.8
7–8 p. m.	27	36	18	3.6	4.9	2.4	7.6	7.3	7.7
8–9 p. m.	28	39	17	3.8	4.6	2.0	8.6	8.4	8.8
9–10 p. m.	31	38	23	3.8	4.3	2.4	9.4	8.9	9.8
10–11 p. m.	28	42	14	3.5	4.7	2.4	7.5	9.0	6.0
11–12 p. m.	28	42	14	3.7	4.5	2.8	7.0	9.2	4.9

In order to diminish the accidental fluctuations it seemed advisable to adjust the data of Table 4 by using the formula $b' = \frac{1}{4}(a+2b+c)$, where a, b, c, are the originally recorded falls of three successive hourly intervals, and b' is the resulting adjusted value for the second hour. After computing these the values for quantity and duration have been converted into per cents of the daily totals, and thus the curves of fig. 1 have been constructed.

It appears from fig. 1 that the duration presents the least daily fluctuations, they amounting to a little more than 1 per cent. The durations for the two seasons agree very well, both showing the typical maximum between 3 and 6 p. m. This is also the time of maximum quantity. Evidently this maximum is caused by the daily temperature maximum which generally throws the atmosphere into very unstable equilibrium. This statement applies to Apia during the dry season only. In the wet season the northerly winds coming from the high seas favor precipitation. The atmospheric radiation during the night cools the upper strata whereas the lower strata are kept warm by the sea water. Thus a nocturnal unstable equilibrium is to be expected, especially during the rainy season, and owing to this fact the nocturnal rain maximum from 3 to 5 a. m. of the wet season, as shown by the three diagrams, is not surprising. Analyzing the results we obtain the following formulas expressing the departures from the mean average:

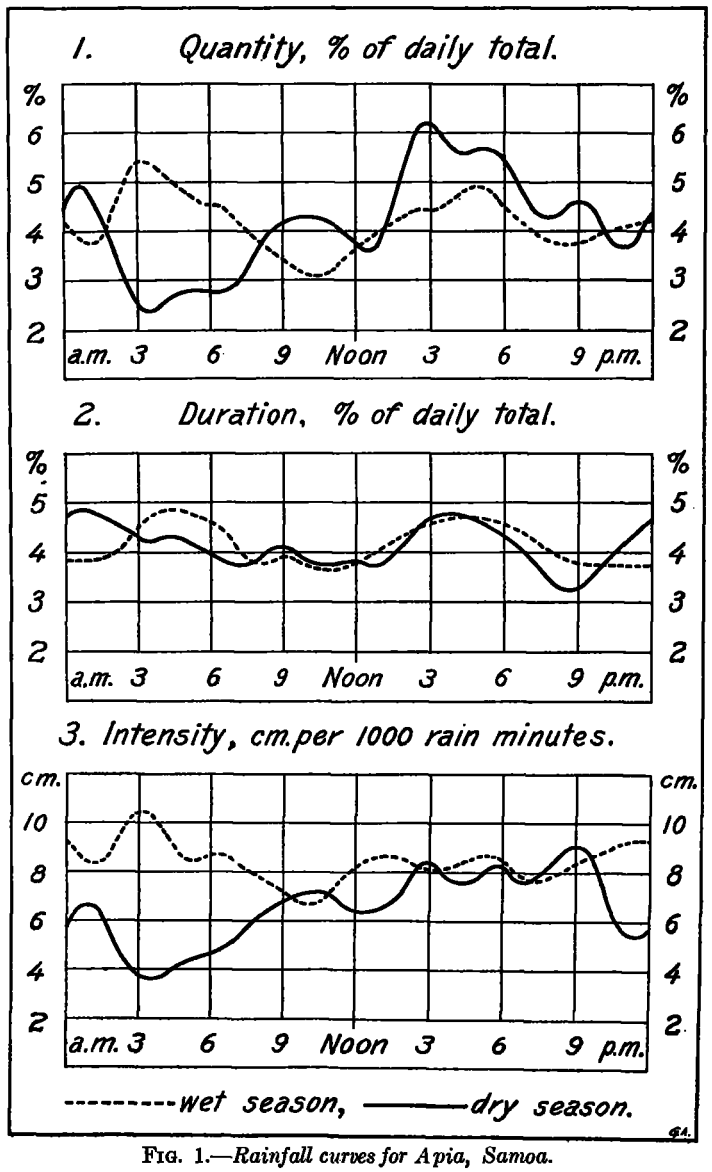

FIG. 1.—*Rainfall curves for Apia, Samoa.*

1. *Quantity:*
   Wet season, $=0.3 \sin(85°+h)+0.7 \sin(324°+2h)$ (1)
   Dry season, $=1.2 \sin(195°+h)+0.2 \sin(395°+2h)$ (2)
2. *Duration:*
   Wet season, $=0.1 \sin(222°+h)+0.5 \sin(310°+2h)$ (3)
   Dry season, $=0.1 \sin(116°+h)+0.4 \sin(358°+2h)$ (4)
3. *Intensity:*
   Wet season, $=0.7 \sin(82°-h)+0.6 \sin(358°+2h)$ (5)
   Dry season, $=1.8 \sin(195°-h)+0.7 \sin(166°+2h)$ (6)

These analytic formulas verify the previous statements. In Quantity and Intensity the first term's angular values agree very well, placing the daily maximum according to the thermal influence. The second term's angular values are equal in Quantity and Duration causing two maxima from 3^h-4^h, two minima from 9^h-10^h. These double daily periods of rain may be explained by the fluctuations in atmospheric pressure. The two phenomena are exactly opposite in phase. According to formulas 1 and 2 the variation of Quantity is about 0.07 millimeters during the wet season and 0.01 during the dry season.

It must now be seen if these amounts may be explained by the daily tropical fluctuations of the barometer. We have the equations:

$$dQ=c_v.\,dt+Apdv,$$
$$pv=RT,$$
$$AR=c_p-c_v, \text{ where}$$

dQ=the quantity of heat given to a certain quantity of air,
c_p=the specific weight (=0.238) of air at a constant pressure, p.
c_v=the specific weight of air at a constant volume, v.
A=the reciprocal thermal equivalent (1/427).
p=pressure (=760 mm.)
v=volume.
R=constant of the gas (=29.3).
t=centigrade temperature of the gas.
T=absolute temperature ($=300°A$).

From the above equations we easily derive the following ones:

$$pdv+vdp=Rdt,$$
$$dQ=c_v dt+ARTdt-Avdp,$$
$$dQ=c_v dt-ART.\frac{dp}{p}.$$

The adiabatic condition gives $dQ=0$, from which we derive

$$dt=\frac{ARTdp}{c_v p}.$$

By substituting the above given values of the different quantities in this equation the result is

$$dt=0.114\,dp,$$

therefore the mean daily fluctuations of the air pressure amounting to more than 1 millimeter cause temperature fluctuations of more than $0.1°C$. Saturated air at about $25°C$. condenses more than 0.1 gram water per cubic meter for a decrease of $0.1°C$. in temperature, or more than 100 grams per 1,000 cubic meters. This quantity is equivalent to a precipitation of 0.1 millimeter over an area of 1 square meter. Although the air is not always near the point of saturation, yet the quantity ascribable to the daily barometric fluctuations is sufficient to explain the above-mentioned daily amplitude of 0.07 millimeter.

Since the rainfall is usually observed but twice a day in the Tropics, 6 a. m. and 6 p. m., it is of interest to figure the daily and nightly percentage. The result is as follows:

Percentage of day and night precipitation, Apia, Samoa.

Period.	Night.	Day.
	%	%
Year	50.0	50.0
Wet season	51.5	48.5
Dry season	46.4	53.6

GRADES OF RAIN.

In reference to the rain quantity fallen during certain intervals of time, for example hours or days, a new gradation of rain has been introduced. As the soil, plants, tanks, etc., are unable to absorb more than a certain quantity of rain, the excess is obliged to overflow and thereby become useless. From a practical point of view the usual "additive" scale seems to overestimate the amount of rain falling at one time; and so in order to find a more adequate gradation a logarithmic scale seemed the most satisfactory. The rain being subject to the physical sensibilities of mankind Weber's law[2] becomes applicable which also requires a logarithmic gradation.

Considering 0.1 millimeter as unity and $10^{\frac{1}{2}}$ as the ratio of quantities corresponding to two succeeding grades, the values for whole grades are .....10^0, $10^{\frac{1}{2}}$, 10^1, $10^{\frac{3}{2}}$, 10^2, etc.
which equal..... 1, 3.16, 10, 31.6, 100, etc.
The limits of two succeeding grades are.. $10^{\frac{1}{4}}$, $10^{\frac{3}{4}}$, $10^{\frac{5}{4}}$, etc.
which equal.....1.78, 5.63, 17.78, etc.

When it is desired to convert these quantities into inches, considering 0.01 inch as unity, the above figures are multiplied by 0.3937.

Hence Table 6 is derived.

TABLE 6.—*Table of rain "grades" and their equivalents.*

Grade of rain.	Quantity measured.	
	Unity=0.1 mm.	Unity=0.01 inch.
0	½ and less	¼ and less
1	1	½
2	from 2 to 5	1 and 2
3	from 6 to 17	from 3 to 7
4	from 18 to 56	from 8 to 22
5	from 57 to 177	from 23 to 70
6	from 178 to 562	from 71 to 221
7	from 563 to 1778	from 222 to 700
8	from 1779 to 5623	from 701 to 2213

In Samoa the rain falls in large quantities, and therefore it might be permissible in the original work to class falls of 0.1 millimeter and less in the 0-grade of rain; but in order that this method of classifying rainfalls may find application in discussions of dryer climates this Summary has classed precipitations of 0.05 millimeter and less in grade 0, and 0.1 millimeter in grade 1.

Hourly rain "grades."

This method of expressing rainfalls by "grades" makes it possible to publish on one page the hourly records of a self-registering rain-gage for 12 months. As an example the wet and dry seasons of November, 1902 to October, 1903, are given in Table 7.

From these 12 months of single hourly rain "grades" tables 8, 9, 10, and 11 are derived. Table 8 shows for each month the number of hours characterized by each "grade." It appears that "grades" 3–6 are the most frequent during the wet season, whereas the average "grade" for the rain hours is not very different for the two seasons.

[2] Weber's Law, Fechner's Law, or the Psycho-physical Law, may be formulated thus—"The difference between any two stimuli is experienced as of equal magnitude, in case the mathematical relation of these stimuli remains unaltered Or, otherwise expressed: In order that the intensity of a sensation may increase in mathematical progression, the stimulus must increase in geometrical progression. It is also expressed by Fechner in the form: The sensation increases as the logarithm of the stimulus." For example, "If we can distinguish 16 oz. and 17 oz., we shall we able to distinguish 32 oz. and 34 oz., but not 32 oz. and 33 oz., the addition being in each case, for example, 1/16 of the preceding stimulus."—*Enclyclopedia Britannica*, 1888–91. *Ninth edition. Vol.* 24, *p.* 469. *Art. "Weber's Law."*

TABLE 7.—*Hourly "grades" of rain at Apia, Samoa, 1902–1903.*

WET SEASON.

1902.	a.m. 6	a.m.	M.	p.m. 6	p.m.
Nov. 1	.....	.....	.....	.....	.....
	.....	.....	.....	.3..21	.....
	..20..	2..452	2....2	.....	.....
	..3.4.	....3.	20....	.....	.....
	.....	.....	.....	...3..	.....
6	43301.	..4...	.....	.....	.....
	..2...	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	....3.	..1...	.....	.....
	.....	.....	.....	13	.....
11	.....	.....	2	.....	.....
	...53.	.....	.....	.....	.....
	.....	.....	.....	2	.....
	.1.20.	3	5331..	.....	.....
	.....	.....	.....	.....	.....
16	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
21	.....	..35..	.15...	4	.....
	...244	4251.5	1.41..	.3243.	.....
	3.533.	32....	.....	4...2	.....
	.....	..3321	.13443	523...	.....
	3	1..4..	50..40	.....	.....
26	.....	.....	.....	.....	.....
	.....	.....	2....5	43.1..	.....
	30	1.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
Dec. 1	...0..	.....	.....	.....	.....
	.13...	3.....	...423	....1.	.....
	....1.	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
6	..32..	.....	.....	....3.	.....
	..2.2.	.....	33.41.	.....	.....
	...01.	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
11	.....	.....	.....	.....	.....
	.....	.....	..1...	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	12	.20231	222121	..4543	.....
16	033354	.....	1	.....	.....
	.....	.....	.....	.30...	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
21	.....	.....	.....	.....	.....
	.....	.....	.....	.00413	.....
	1	3.....	...3..	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
26	.....	.....	54	42....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.44421	0.....	.....	.....
31	.....	.....	.....	.....	.....
1903.					
Jan. 1	2	533355	544424	2.22..	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.42444	232....	.....	.....
6	.....	...321	.3442.	.....	.....
	.....	22	10....	..0...	.....
	...432	.4....	.....	.....	.....
	.....	..2...	3	. 2455	.....
	645432	..110.	.....	.....	.....
11	53	.45424	43..31	.0....	.....
	....3.	342...	332444	545641	.....
	146632	332100	10....	.....	.....
	.....	3	2.....	.....	.....
	.....	22	.....	.....	.....
16	401134	44431.	5	31....	.....
	1..12.	..401.	.....	.....	.....
	.....	.....	...23.	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	42	.....
21	...20.	.....	.....	.....	.....
	.03121	.22321	1..0..	.....	.....
	.....	...01.	.....	20	.....
	431.1.	.23301	0.....	..332.	.....
	.....	.....	.....	.....	.....
26	.....	.....	.....	..503.	.....
	30343.	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
31	.....	.....	.....	...32.	.....

1903.	a.m. 6	a.m	M.	p.m. 6	p.m.
Feb. 1	34....	.....	.....	.....	.....
	.....	...40.	.. ...	31	.....
	.....	.....	.....	.....	.....
	.....	.....	....1.	.....	.....
	...233	3110..	.....	.....	.....
6	1...1.	.....	.32...	.....	.....
	.....	.....	.0....	..41.3	.....
	0...21	.144..	.51..	...2..	.....
	12.0..	44	253655	432...	.....
	.....	..1223	454566	654445	.....
11	556666	554042	143442	0.22.0	.....
	13513.	...325	655544	41.365	.....
	551455	334.21	.35445	0343.2	.....
	3242.1	.3....	.5431.	..4321	.....
	1.....	.....	.....	.....	.....
16	3	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	3.....	.....	.....	.....	.....
	.....	.....	.....	3	.....
	.....	.....	.....	.....	.....
21	.....	.....	.....	.....	.....
	...4..	45	1	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
26	2.....	4432.2	....0.	.....	.....
	4.....	.....	.4023.	.....	.....
	.....	.....	...22.	.....	.....
Mar. 1	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.1....	.....	.....
	.....	.....	.....	.....	.....
6	.....	52	434554	3.....	.....
	.1....	.....	.....	.....	.....
	.....	...3..	.32332	12241.	.....
	52313.	2.14..	13....	442432	.....
	123243	31....	..4...	.....	.....
11	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	...213	...2..	.....	.....	.....
16	.....	.....	 3	.20...	.....
	.11423	4.121.	..32.0	2122..	.....
	33	31....	.....	.....	.....
	.....	44	3..2..	.....	.....
	.....	.....	.....	.....	.....
21	.....	.....	.....	.....	.....
	.....	.....	.....	.24..1	.....
	.....	.....	4.....	.3342.	.....
	41	.....	05	440335	.....
	2..2..	.....	.....	.....	.....
26	.....	.....	.....	.....	.....
	.....	.....	.....	.0....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
31	.....	.....	.....	.....	.....
April 1	.....	.....	.....	.....	.....
	.....	.....	.....	135..4	.....
	40..23	343442	1...1.	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	321...	.....
6	.....	.....	.....	.451..	.....
	...544	0.....	.....	2	.....
	.....	.....	.....	3	.....
	1.....	313...	.....	..44.5	.....
	551...	....0..	..60..	.1....	.....
11	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	3.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
16	.....	.....	.....	.....	.....
	.....	.2521.	.....	36	.....
	321..2	.....	...255	23....	.....
	...253	.33331	2	.3.2.	.....
	...11.	..3434	4153..	.22...	.....
21	.33433	31....	.....	30..35	.....
	332...	212..0	1.....	...253	.....
	34	..1...	..3444	5542.1	.....
	2.....	.....	..3210	.53224	.....
	4444.2	333345	544455	2.111.	.....
26	.....	.....	.....	.....	.....
	.....	.....	30	.....	.....
	.....	.....	.....	2.....	.....
	.....	.....	.....	.....	.....
30	.....	.....	.....	.....	.....

DRY SEASON.

1903.	a.m. 6	a.m.	M.	p.m. 6	p.m.
May 1	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	....1.	.....	.....
6	13....	.....	.....	3.....	.....
	.....	.....	.....	.....	.....
	.....	.1....	..52..	...11.	.....
	.....	.....	.11...	.....	.....
	.....	.....	.....	.....	.....
11	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	3	2.....	213402	.....
	341...	03	0....2	2310.4	.....
	1...1.	...2..	3	1....4	.....
16	44...4	131...	1..2..	.....	.....
	...04.	2.4...	...4..	2....2	.....
	..30..	.....	.....	1.....	.....
	.....	.14100	21..24	54442.	.....
	1.....	.....	.....	.....	.....
21	...020	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	...33.	.45444	.....
	432.23	121...	.....	.....	.....
	.....	.....	.....	.....	.....
26	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
31	.....	.....	.....	.....	.....
June 1	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	..2...	.....	231...	.....
	....1.	34	221...	...454	.....
	32....	.....	.....	.....	.....
6	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	352...	.....
	...1..	1	12..2.	32....	.....
	...122	2.....	.....	.....	.....
11	.....	.....	.....	.....	.....
	.....	.....	...52.	1.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.621.2	1....0	.1.34.	.....	.....
16	...22.	1	.....	.....	.....
	.20...	...22.	2..451	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
21	.....	.....	.....	.....	.....
	.....	..341.	.1.2..	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	...101	.....
	3.....	.....	.203.5	223432	.....
26	46533.	444332	445645	334553	.....
	344.3.	.....	.....	24....	.....
	.....	.....	.....	.....	.....
	.....	.....	..10..	.....	.....
	11	01.22.	53	43....	.....
July 1	.....	...411	.....	2	.....
	.....	.....	.3.....	.....	.....
	.....	.....	..33..	.....	.....
	.....	.....	.....	2...12	.....
	.22...	4.....	36	2.332.	.....
6	...1..	.24432	34..02	1.....	.....
	.....	.....	..1...	.....	.....
	.51.22	10233.	.0....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
11	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
16	.....	.....	.....	.....	.....
	.....	.....	.....	.120..	.....
	....0.	.....	.....	.....	.....
	02.423	2.....	...22.	.0....	.....
	.....	.....	.....	.....	.....
21	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
26	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.2....	.....	.....	.....
	.....	.....	.....	.....	.....
	.1....	4.....	.....	.....	.....
31	.....	.....	.....	.....	.....

1903.	a.m. 6	a.m.	M.	p.m. 6	p.m.
Aug. 1	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	022021	0.....	.....	.....
	.....	.....	.....	.....	.....
	..3221	1.....	.....	.....	.....
6	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	....0.	42.431
	34444.	.1.3..	.....	.....	.....
11	.0...1	333353	.0.122	....0.	.....
	12....	.110..	.....	4	.....
	.....	.....	.....	.2..31	.....
	..1311	.....	.....	.....	.....
	.45445	350..2	2.....	.....	.....
16	.....	.....	....3.	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
21	.....	.....	.....	.....	.....
	.....	.....	.3....	.....	.....
	.2...1	..1...	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
26	.....	1..3..	.....	2	.....
	2....1	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	2.....	.....	3	.....	.....
	.....	1.2100	3.....	.1232.	.....
31	04....	.....	.....	.....	.....
Sept. 1	.....	.....	.....	.....	.....
	.....	.....	2.4154	4....2	.....
	51...1	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
6	.....	.....	.....	.3....	.....
	.....	.....	.....	.....	.....
	.....	.....	...1..	.....	.....
	.....	.....	.....	...0.2	.....
11	.....	...311	05	320135	.....
	.1..11	.....	0343..	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
16	...344	3.....	.....	32	.....
	2.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	4	10....	.....	.....
	.....	32....	.....	.....	.....
21	.....	.....	.....	.....	.....
	.....	.....	....2.	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
26	.....	...0..	.....	.....	.....
	.....	.....	.....	.3....	.....
	3.1..4	53.634	334554	5652..	.....
	..0.1.	.....	1	21...0	.....
	201...	...3.3	0.....	2.....	.....
Oct. 1	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	...1..	.0...2	.....	.....
	.....	.....	.....	.....	.....
	..2...	32132.	.42.1.	202...	.....
6	1.1441	.....	.....	.....	.....
	.....	.....	.....	.1	.23244
	441...	.....	.....	.....	.....
	.....	.....	....1.	.....	.....
	.....	.....	.....	.....	.....
11	0	...24.	..313.	.34663	.....
	344323	3421..	..5554	220...	.....
	1.....	.....	.....	.22.44	.....
	130444	.43556	422312	34321.	.....
	...03.	.....	..30.2	1	.....
16	5531..	.321..	...51.	4....2	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	...221	.....	.....	.....	.....
	.....	.....	.....	.....	.....
21	.....	.....	.....	.....	.....
	.....	.....	.....	2	430..3
	1.....	.44...	.....	.....	.....
	.1..4.	.....	...13.	10....	.....
	.....	...0.3	.....	.1..3.	.....
26	53431.	6	52....	...21.	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
	...11..	...3..	.....	.....	.....
31	.....	.....	.....	.....	.....

TABLE 8.—*The number of hours each rain "grade" occurred at Apia, Samoa, November, 1902, to October, 1903.*

Season.	Number of hours with grade								Number of hours with rain.	Average grade of the rain hours.
	No rain.	0	1	2	3	4	5	6		
Wet season.										
November	635	7	15	19	27	16	11	0	95	2.7
December	679	8	14	15	14	11	3	0	65	2.2
January	579	18	23	36	36	35	13	4	165	2.6
February	513	11	23	26	28	35	26	10	159	3.1
March	645	5	18	25	25	20	6	0	99	2.6
April	572	8	24	30	36	28	20	2	148	2.8
Dry season.										
May	656	10	23	20	12	20	3	0	88	2.2
June	608	6	21	30	22	19	11	3	112	2.6
July	657	7	10	20	11	7	1	1	57	2.1
August	659	12	21	21	16	11	4	0	85	2.1
September	642	10	16	13	17	11	9	2	78	2.5
October	608	10	29	28	28	27	10	4	136	2.6
Year.	7473	112	237	283	272	240	117	26	1287	2.6
Wet season	3613	57	117	151	166	145	79	16	731	2.7
Dry season	3860	55	120	132	106	95	38	10	556	2.4
Seasonal ratio	0.94	1.04	0.97	1.14	1.57	1.53	2.08	1.60	1.31	1.4

Table 9 gives a summary of the time characterized by hourly rain "grades." Two or more rainfalls, in the usual meaning of that term and of the previous statistics based on rain minutes, are now represented by one "grade" number unless their interval covers the full hour and then a period appears in Table 7 of hourly "grades."

TABLE 9.—*Frequency and intensity of rainfalls of various durations in "grade" hours. Apia, Samoa, 1902–1903.*

Rainfalls (=Successive hours with rain).

Number of successive hours showing "grades."	Number of rainfalls lasting			Sum of hours occupied by falls lasting			Intensity, average hourly "grade."			Sum of hourly "grades" for falls lasting		
	h 1-3	h 4-12	h >12	h 1-3	h 4-12	h >12	h 1-3	h 4-12	h >12	h 1-3	h 4-12	h >12
Wet season.				*hrs.*	*hrs.*	*hrs.*						
November	38	7	0	58	37	0	2.5	2.9	.....	146	107	0
December	19	5	0	29	36	0	2.0	2.4	.....	57	88	0
January	26	12	2	52	75	40	2.1	2.7	3.2	111	200	128
February	30	11	1	44	78	35	2.1	3.2	3.9	93	251	138
March	21	8	1	33	52	14	2.2	2.7	2.7	73	142	38
April	30	13	1	57	77	14	2.3	3.1	3.7	124	240	52
Dry season.												
May	27	7	0	43	45	0	2.0	2.4	.....	85	109	0
June	29	7	1	53	38	21	2.1	2.7	3.9	112	102	82
July	23	3	0	39	18	0	1.9	2.6	.....	76	46	0
August	27	8	0	37	48	0	1.7	2.3	.....	63	112	0
September	25	5	1	40	25	13	1.9	2.6	4.2	75	64	55
October	41	7	2	64	41	31	2.0	3.0	3.3	128	122	101
Year.	336	93	9	549	570	168	2.1	2.8	3.5	1143	1583	594
Wet season	164	56	5	273	355	103	2.2	2.9	3.5	604	1028	356
Dry season	172	37	4	276	215	65	2.0	2.6	3.7	539	555	238
Seasonal ratio	0.95	1.51	1.25	0.99	1.65	1.58	1.10	1.12	0.95	1.12	1.35	1.50

A comparison shows that the number of rainfalls as computed by the "grade" hours, amount to about 4/10 of the number obtained in the usual way, by counting by minutes. In all four columns of Table 9 the rainfalls are divided into three groups, viz, those lasting from 1–3, from 4–12, and more than 12 successive "grade" hours. The group 4–12h. gives the highest seasonal ratio in each of the four columns.

Table 10 gives the daily arithmetical totals of the hourly "grades" as given in Table 7, and this is summarized in Table 11 which shows the number of days characterized by various groups of daily "grade" totals. The group embracing totals from 30 to 59 in Table 11 gives the largest seasonal ratio. The monthly averages and totals given in the last three columns of that table also bring out distinctly the difference between the two seasons.

TABLE 11.—*Number of days having various total hourly rain "grades." Apia, Samoa, 1902–1903.*

Daily totals of hourly "grades."	Number of days with						Average daily total for all days.	Monthly total.	Average daily total for the rain days.
	No rain.	0 to 9	10 to 29	30 to 59	60 to 99	>99			
Wet season.									
November	11	9	8	2	0	0	8	253	13
December	17	8	5	1	0	0	5	145	10
January	8	10	8	5	0	0	14	432	19
February	7	10	5	2	4	0	17	489	23
March	15	7	6	3	0	0	8	253	16
April	10	5	10	4	1	0	14	416	21
Dry season.									
May	16	6	8	1	0	0	6	194	13
June	13	7	9	0	1	0	10	296	17
July	18	9	4	0	0	0	4	122	9
August	14	12	4	1	0	0	6	175	10
September	13	11	5	0	1	0	6	194	11
October	11	9	6	4	1	0	11	351	18
Year.	153	103	78	23	8	0	9	277	16
Wet season	68	49	42	17	5	0	11	331	18
Dry season	85	54	36	6	3	0	7	222	13
Seasonal ratio	0.8	0.9	1.2	2.8	1.7	.....	1.6	1.5	1.4

Daily rain "grades."

According to a long established custom eye observations of rainfall are usually made but once during 24 hours, it therefore seems advisable and of general interest to compare the daily quantities of rain with those of the hourly grades referred to in this summary. Table 12 gives the daily "grades" for the first two seasons observed.

From Table 12 the statistics presented in Table 13 have been derived, showing that the two seasons are best characterized by the daily grade 6, grade 7 and 8 happen too seldom and the grades below 6 in the wet season do not predominate over the same in the dry season. The monthly totals of the daily grades give the seasonal ratio 1.3 which is only one-half of that given by grade 6, but still it is sufficient to characterize the two seasons in regard to the benefits derived from the rainfall.

TABLE 10.—*Daily arithmetical totals of hourly rain "grades" at Apia, Samoa, 1902–1903.*

Day.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Wet season.																															
November	.	6	19	12	3	15	2	.	4	4	2	8	2	18	.	.	.	.	.	.	18	45	25	34	17	.	15	4	.	.	—
December	0	17	1	.	.	8	15	1	.	.	.	1	.	.	36	18	3	.	.	.	.	8	7	.	.	15	.	.	.	15	.
January	55	.	.	.	25	19	5	13	21	26	38	57	32	5	4	38	8	5	.	6	2	18	3	26	.	8	13	.	.	.	5
February	7	8	.	1	13	7	8	20	46	66	76	70	71	38	1	3	.	3	3	.	.	14	.	.	.	17	13	4	—	—	—
March	.	.	.	1	.	35	1	26	44	23	.	.	.	.	8	5	31	10	13	.	.	7	16	29	4	.	0	.	.	.	.
April	.	13	31	.	6	10	13	2	21	18	.	.	3	.	.	.	19	25	28	32	31	24	40	24	71	.	3	2	.	.	—
Dry season.																															
May	.	.	.	.	1	7	.	10	2	.	.	.	17	22	12	20	18	3	34	1	2	.	27	18	.	.	.	.	.	.	.
June	.	.	8	26	5	.	.	10	12	7	.	8	.	.	20	5	18	.	.	.	.	11	.	2	29	92	20	.	1	22	—
July	8	3	6	5	27	26	1	19	.	.	.	.	.	.	.	.	3	0	17	.	.	.	.	.	.	.	.	2	.	5	.
August	.	.	7	.	8	.	.	.	14	23	26	9	6	5	34	3	.	.	.	.	.	3	4	.	.	6	3	.	5	15	4
September	.	22	7	.	.	2	.	1	.	2	24	13	.	.	.	19	2	.	5	5	.	2	.	.	.	0	3	71	5	11	—
October	.	.	3	.	24	11	16	9	1	.	35	52	13	66	9	32	.	.	5	.	.	12	9	10	7	32	.	.	.	3	2

TABLE 12.—*Daily rain "grades," Apia, Samoa, 1902–1903.*

Day.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Wet season.																															
November	.	3	5	4	3	5	2	.	3	3	2	5	2	5	.	.	.	.	.	.	6	6	6	6	6	.	6	3	.	.	—
December	0	5	1	.	.	4	4	1	.	.	.	1	.	.	6	6	3	.	.	.	.	4	4	.	.	6	.	.	.	5	.
January	7	.	.	.	5	5	3	5	6	6	6	7	7	3	3	6	4	3	.	4	2	4	2	5	.	5	4	.	.	.	3
February	4	4	.	1	4	3	5	5	7	7	8	7	7	6	1	3	.	3	3	.	.	5	.	.	.	5	5	3	—	—	—
March	.	.	.	1	.	6	1	5	6	5	.	.	.	.	3	4	5	4	5	.	.	4	5	6	3	.	0	.	.	.	.
April	.	5	5	.	3	5	6	2	6	6	.	.	3	.	.	.	6	6	6	6	6	5	6	5	7	.	3	2	.	.	—
Dry season.																															
May	.	.	.	.	1	3	.	5	2	.	.	.	5	5	4	5	5	2	6	1	2	.	6	5	.	.	.	.	.	.	.
June	.	.	3	6	3	.	.	5	4	3	.	5	.	.	6	3	5	.	.	.	.	4	.	2	5	7	5	.	1	6	—
July	4	3	4	2	6	5	1	5	.	.	.	.	.	.	.	.	3	0	5	.	.	.	.	.	2	.	.	.	.	4	.
August	.	.	3	.	3	.	.	.	5	5	6	4	3	3	6	3	.	.	.	.	.	3	2	.	.	3	2	.	3	4	4
September	.	6	5	.	.	2	.	1	.	2	5	5	.	.	.	5	2	.	4	3	.	2	.	.	.	0	3	7	2	4	—
October	.	.	2	.	5	5	5	4	1	.	7	6	5	7	3	6	.	.	3	.	.	5	5	4	4	7	.	.	.	3	2

TABLE 13.—*Frequency of various daily rain "grades." Apia, Samoa, 1902–1903.*

Season.	Number of days having daily "grade"										Totals.
	No rain.	0	1	2	3	4	5	6	7	8	
Wet season.											
November	11	0	0	3	5	1	4	6	0	0	81
December	17	1	3	0	1	4	2	3	0	0	50
January	8	0	0	2	5	4	5	4	3	0	105
February	7	0	2	0	5	3	5	1	4	1	96
March	15	1	2	0	2	3	5	3	0	0	63
April	10	0	0	2	3	0	5	9	1	0	99
Dry season.											
May	16	0	2	3	1	1	6	2	0	0	57
June	13	0	1	1	4	2	5	3	1	0	73
July	18	1	1	2	2	3	3	1	0	0	44
August	14	0	0	2	8	3	3	2	0	0	62
September	13	1	1	5	2	2	4	1	1	0	58
October	11	0	1	2	3	3	6	2	3	0	89
Year.	153	4	13	22	41	29	52	37	13	1	877
Wet season	68	2	7	7	21	15	26	26	8	1	494
Dry season	85	2	6	15	20	14	26	11	5	0	383
Seasonal ratio	0.80	1.00	1.17	0.47	1.05	1.07	1.00	2.36	1.60	∞	1.29

The same ratio, when computed from the hourly "grades," is 1.5, whereas the ratio from rain quantities measured in the customary "additive" manner is 1.8. It can safely be expected that a similar proportion will exist in other rain statistics.

Table 14 shows the average daily "grades" for each month of the eight different seasons observed. The "character" of each season is given below and shows distinctly the great variation from year to year. Only the daily "grades" for the rain days do not show remarkable features, the individual monthly average of the wet season varying between 3.5 and 5.0, and for the dry season between 2.4 and 4.4. The average values for the two seasons are 4.3 and 3.7 and characterize the seasonal difference very slightly.

WIND DIRECTIONS AND RAIN.

For the year 1906 the wind registrations are quite complete, and the statistics given in Table 15 have been obtained.

These percentages when divided by one hundred give the respective probabilities. Thus it appears that the tradewinds, during both seasons, afford a smaller rain probability than the

TABLE 14.—*The mean daily rain "grades" for each month of the period, November, 1902,—December, 1906, Apia, Samoa.*

Months.	For all days.						For the rain days.					
	1902–1903.	1903–1904.	1904–1905.	1905–1906.	1906.	Average Nov., 1902, to Oct., 1906.	1902–1903.	1903–1904.	1904–1905.	1905–1906.	1906.	Average Nov., 1902, to Oct., 1906.
Wet season.												
November	2.7	3.3	2.6	2.1	3.2	2.7	4.3	4.3	3.5	4.6	4.6	4.1
December	1.6	2.9	3.2	2.2	3.2	2.5	3.6	4.5	4.2	5.5	4.0	4.0
January	3.4	4.2	3.3	2.4	.....	3.3	4.6	4.7	4.7	4.1	.....	4.5
February	3.4	4.3	2.5	3.3	.....	3.1	4.6	4.6	4.6	3.6	.....	4.4
March	2.0	3.1	2.5	3.5	.....	2.8	3.9	4.8	4.1	4.5	.....	4.3
April	3.3	4.2	2.4	2.9	.....	3.2	5.0	4.7	3.8	3.7	.....	4.3
Dry season.												
May	1.8	2.2	0.5	2.2	.....	1.7	3.8	3.6	2.4	4.2	.....	3.7
June	2.4	1.5	1.4	2.7	.....	2.0	4.3	3.8	3.9	4.2	.....	4.1
July	1.4	1.8	1.0	2.1	.....	1.6	3.4	4.2	3.2	3.8	.....	3.7
August	2.0	2.2	1.6	2.3	.....	2.0	3.6	3.7	3.8	3.5	.....	3.6
September	1.9	2.4	1.4	1.6	.....	1.8	3.4	3.4	4.1	3.5	.....	3.5
October	2.9	2.0	1.6	2.2	.....	2.2	4.4	3.8	3.6	3.4	.....	3.8
Year.	2.4	2.8	2.0	2.4	.....	2.4	4.1	4.2	3.9	3.9	.....	4.1
Wet season	2.7	3.6	2.8	2.6	.....	2.9	4.4	4.6	4.1	4.0	.....	4.3
Dry season	2.1	2.0	1.3	2.2	.....	1.9	3.9	3.7	3.6	3.8	.....	3.7
Character:												
Wet season	(+0.12)	+0.25	+0.24	+0.19	.....	.....	(+0.05)	+0.08	+0.05	+0.04	.....	.....
Dry season	−0.18	−0.20	−0.32	(−0.07)	.....	.....	−0.06	−0.07	−0.06	(−0.03)	.....	.....

average of all winds. During the dry season a much higher rain probability is presented by the south to west-northwest winds, evidently because atmospheric disturbances are accompanied by these winds.

TABLE 15.—*Wind direction and rain.*

1906.	Wet months.			Dry months.		
Regardless of wind directions, rain hours, per cent of all hours	14.7			10.9		
Group of winds	NW to NE.	ENE to SSE	S to WNW	NW to NE	ENE to SSE	S to WNW
Winds, per cent of all winds	14.0	58.6	25.6	6.3	89.6	2.2
Rain hours, per cent of all rain hours	16.8	53.2	23.2	6.8	87.5	4.4
Rain hours, per cent of all hours of the special wind group	17.6	13.3	13.3	11.9	10.6	21.6

The northwest to northeast winds change remarkably from one season to the other. During the wet season they are the rain-bringing winds as they come from the high seas; but during the dry season they are dry and therefore seem in fact to be trade winds which are shifted by the sea breeze and come from the north.

WEATHER NOTES FROM PUERTO PLATA, DOMINICAN REPUBLIC.

By R.J. TOTTEN, U. S. Consul. Dated Puerto Plata, D. R., August 14, 1909.

The Tacajo Cacao and Sugar Company, whose banana plantation lies at Sosua in the province of Puerto Plata, has published from time to time a series of weather notes. From these notes the following summary for the fiscal year, July 1, 1908–June 30, 1909, has been compiled.

The total rainfall for this period was 110 inches, distributed as follows:

TABLE 1.—*Monthly rainfall at Puerto Plata, D. R.*, 1908–9.

1908.		1909.	
	Inches.		*Inches.*
July	6.75	January	20.90
August	1.45	February	8.35
September	19.75	March	1.85
October	6.90	April	1.35
November	12.90	May	8.05
December	13.85	June	7.90

The average monthly rainfall was 9.16 inches. The heaviest rainfall registered in any one day was 9.10 inches on September 10, 1908.

The highest temperature recorded during this period was 94° F., on July 12, 1908, the lowest was 62°, on January 19, 1909. The maximum and minimum temperatures recorded in each month follow:

TABLE 2.—*Monthly temperature extremes at Puerto Plata, D. R.*, 1908–9.

1908.	Max.	Min.	1909.	Max.	Min.
	°F.	°F.		°F.	°F.
July	94	77	January	81	62
August	93	80	February	80	70
September	92	73	March	86	71
October	86	78	April	86	74
November	85	76	May	87	74
December	84	72	June	87	70

The average mean temperature for the year was 79° F.

The prevailing winds are east-northeast and are commonly known as "Local Trades." Average velocity of wind 6 miles per hour.

The highest recorded barometer reading was 30.45 inches, the lowest was 28.25 inches.

CHANGES IN THE MONTHLY WEATHER REVIEW.

In the issues of the MONTHLY WEATHER REVIEW for February and March, 1909, we published in full all the pertinent parts of orders issued by the Chief of the U. S. Weather Bureau, outlining changes which he planned to make in the character of the REVIEW beginning with the issue for July, 1909. At the beginning of the announcement in the issue for February the following statement was made:

> It appears from the following that those readers particularly interested in *climatological statistics* should request that the REVIEW be continued to their addresses; those who are more interested in theoretical and technical discussions of data should request that the Mount Weather Bulletin be sent them in place of the MONTHLY WEATHER REVIEW.

It appears that there are many who have not read these notices and outlines of prospective changes, and the Weather Bureau is still frequently requested to renew or add to its subscription list recipients who apparently do not realize the character of the new publications.

Our readers are therefore informed that beginning with the issue for July, 1909, the MONTHLY WEATHER REVIEW will be restricted to statistical tables of general climatological data for the whole of the United States. The relatively small amount of accompanying text will summarize the weather conditions of the month in the different districts. It is thus evident that hereafter the REVIEW will be of value only to those advanced students of climates, engineers, etc., who need detailed data for their own discussion.

Few papers of general interest to teachers, except as related to climatology, will be published in the MONTHLY WEATHER REVIEW, and it is not probable that the publication will be of value to those public schools and high schools that have been receiving it heretofore. These circles of readers must now turn to the editors of already existing journals to supply their needs along those lines formerly met, perhaps, by articles in the MONTHLY WEATHER REVIEW.

We may here also take the opportunity to remark that the scope of the articles appearing in the Mount Weather Bulletin will be limited to technical treatments of subjects of advanced research. This will make most of the articles of that publication also beyond the comprehension of the average pupil of the above grades of schools, and make the Bulletin only appropriate for the libraries of colleges and universities.—*C. A.*

TORNADOES IN MISSOURI.

On April 29 a very destructive tornado passed through Golden, Barry County, killing nineteen or twenty persons and injuring about eighteen others. Property amounting to nearly $20,000 was destroyed within the village and probably as much more along the route of the storm northeastward to Viola, Stone County, where two or three persons were killed and nine seriously hurt. A number of citizens saw the approaching storm and describe it as resembling the smoke of a railway engine. It was not accompanied by rain or hail. Nearly all the trees blown down by the tornado fell in the direction whence it came, the trees to the southwest being badly battered and bruised as usual. Chickens were picked of their feathers and some were torn to pieces. It is reported that the large amount of atmospheric electricity present increased the difficulties of telephoning to Golden.

Another tornado visited Alton, Oregon County, on this same date, destroying most of the buildings of the town and killing six persons.—*C. A., jr.*

TORNADO AT ANNISTON, ALA.

By W. F. CLARK, Assistant Observer. Dated Anniston, Ala., May 8, 1909.

On April 13, 1909, at about 3 a. m., a small tornado traversed Calhoun County, Ala., from southwest to northeast, passing